The piezoelectric element reed may be characterized as a bimorph, and more particularly may be a parallel polled bimorph. In a particular embodiment, the piezoelectric element reed is a parallel polled bimorph having a top piezoelectric plate, a bottom piezoelectric plate, and a conductive strip positioned between the top plate and the bottom plate and insulated therefrom, the conductive strip extending beyond the top plate and the bottom plate at a first end of the reed. Utilizing the parallel polled bimorph, the piezoelectric element reed is conductively secured to the printed circuit board at a first end of the reed. Additionally, a series polled bimorph is within the scope of the present invention.

According to a particular embodiment, the piezoelectric element reeds are of substantially equal length, and are secured to the printed circuit board in a stepped pattern in a common bending plane.

The plurality of multiple element conductive supports secured to the printed circuit board further include a conductive base, and a plurality of conductive flexion members integral to the conductive base. A variety of designs of the multiple element conductive support are effective in meeting the requirements of providing support and an electrical connection to one side of the bimorph reed. In a preferred embodiment, the plurality of conductive flexion members further comprises an arm including a substantially convex portion, the convex portion being biased in a direction to contact the piezoelectric element reed. The flexion members may be positioned in a stepped pattern relative to the conductive base. Accordingly, the piezoelectric element reeds are positioned between the flexion member and the conductive fulcrum pin to secure them to the printed circuit board and provide the required electrical connections. With this embodiment, the flexion member is in contact with a first electrical contact surface coincident with the top plate and the conductive fulcrum pin is in contact with a second electrical contact surface coincident with the bottom plate of the bimorph. Alternatively, the flexion member may contact the bottom plate and the conductive fulcrum pin may contact the top plate of the bimorph.

In a particular embodiment of the electromechanical tactile cell assembly in accordance with the present invention for use in a Braille display, the plurality of conductive fulcrum pins includes a first plurality of fulcrum pins secured to a first side of the printed circuit board and a second plurality of fulcrum pins secured to a second side of the printed circuit board, and the plurality of multiple element conductive supports includes a first plurality of multiple element conductive supports secured to the first side of the printed circuit board and a second plurality of multiple element conductive supports secured to the second side of the printed circuit board. With this design, six or eight tactile pins of a Braille display can be actuated utilizing both sides of the printed circuit board to present Braille text to a user.

According to another embodiment, an electromechanical tactile cell assembly is provided including a plurality of pin elements secured to the printed circuit board. Each of the plurality of pin elements is slightly offset from a corresponding one of the plurality of multiple element conductive supports thereby creating a fulcrum. Each of the plurality of pin elements, in combination with the corresponding one of the plurality of multiple element conductive supports is adapted to conductively secure the plurality of piezoelectric elements to the printed circuit board. In a specific embodiment, the pin is offset from the conductive support by about 0.2 mm, thereby creating a fulcrum force to bias the bimorph towards the conductive support.

In an additional embodiment, the electromechanical tactile cell includes a removable piezoelectric element negative stop assembly. In an electromechanical tactile cell assembly used to actuate a plurality of tactile pins, a positive stop exists to limit the extension of the pin above the tactile surface. The positive stop is provided by a ridge on the tactile pin positioned at a specific location that abuts against the underside of the tactile surface to limit the extension above the plane. Additionally, a negative stop is needed when a driving voltage is applied to the element reed to retract the pin. This negative stop also serves to reduce the noise and vibration associated with the movement of the reeds. In accordance with the present invention, the negative stop is provided by a removable, nonconductive stop. The removable negative stop assembly further comprises a plurality of negative stop elements corresponding to each of a plurality of piezoelectric elements, the plurality of negative stop elements integral with the removable negative stop assembly. The negative stop assembly is fabricated of an insulative material and positioned proximate to the elongated end portion of the plurality of piezoelectric element reeds. The negative stop assembly is removable, thereby eliminating the additional manufacturing cost of molding the downward stop into a plastic assembly. The downward stop is additionally effective in controlling the piezoelectric element reeds not to be displaced by impact or the like to such an extent that the piezoelectric element reeds are broken by their own displacement.

When employed in a refreshable Braille display, the electromechanical tactile cell assemblies are mounted in a frame. In a particular embodiment, twenty Braille cells are mounted in a hollow frame structure. Each Braille cell includes eight bimorph reeds, such that each Braille cell is effective in presenting a Braille letter to the user. The Braille cell further includes a bus connector adapted to secure the Braille cell assembly to the frame and provide electrical connectivity. In a particular embodiment, a serial to parallel converter in circuit communication with the bus connector is included to receive serial input data from the bus connector for actuation of the plurality of piezoelectric element reeds.

To provide the tactile presentation of the Braille letters to the user, a plurality of tactile pins, each of the plurality of tactile pins corresponding to each of the plurality of piezoelectric element reeds are provided. The tactile pins are vertically movable, in response to a bending movement of a corresponding one of the plurality of piezoelectric element reeds. With this embodiment, the tactile pins are not required as part of the Braille cell assembly. While prior art methods may be used wherein an individual tactile pin cap is provided for each Braille cell, the present invention provides a solution whereby the tactile pins corresponding to a plurality of Braille cell assemblies may be contained in one large tactile pin cap for the entire display. It is within the scope of the invention to provide any number of electromechanical tactile cell assemblies employed in a Braille display or graphic tactile display.

As such, the present invention provides improvements in manufacturability and maintenance of electromechanical tactile cell assemblies. The use of a novel multiple element conductive support and a conductive fulcrum pin eliminates the need for lead wires and hand-solder joints, thereby improving both manufacturability and reliability of the device. Tactile pin maintenance and bimorph reed replacement are greatly simplified with the present invention. Additionally, the present invention enables the use of a tactile pin cap for multiple Braille cell assemblies, thereby eliminating the separation between each cell that is detectable by a user and considered undesirable. The user is presented with a